Immersive Environments for Mission Operations: Beyond Mars Pathfinder

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ABSTRACT

Immersive environments are just beginning to be used to support mission operations at the Jet Propulsion Laboratory. This technology contributed to the Mars Pathfinder Mission in planning sorties for the Sojourner rover. Utilizing stereo imagery from the Imager for Mars Pathfinder (IMP) camera enabled the operator to visualize the terrain from the lander's point of view in 3D to assist in plotting waypoints. In addition, the stereo imagery was used to create 3D terrain models which could be viewed from any angle to provide an additional visualization tool. These technologies contributed heavily to both the mission success and the phenomenal level of public outreach achieved by Mars Pathfinder. This paper will review the utilization of immersive environment technology in support of Mars Pathfinder and discuss development beyond Pathfinder and future directions in detail.

Future developments in immersive environments for mission planning include several tools which make up a system for performing and rehearsing missions. This system includes tools for performing triangulation of landmarks to accurately locate landers and rovers, tools for planning long range sorties for highly autonomous rovers, tools for planning operations with robotic arms, and advanced tools for visualizing telemetry from remote spacecraft and landers. In addition, Web-based tools for scientific collaboration in planning missions, as well as performing public outreach and education, are under development.

The Mars Pathfinder mission used mostly hand calculations to determine landmark visibility within the area of the expected landing site. Tools under development seek to progressively automate the process, beginning with assisted triangulation with operator aids, through automated landmark selection, horizon feature detection, and best-fit feature matching. These automated tools may be included in future rovers to provide onboard feature analysis and triangulation capability. This technology is needed to enable the creation and extension of 3D terrain models from lander and rover imagery.

As rovers can range over greater distances with more autonomy when they have accurate self-locating systems, the operator paradigm shifts from a hands-on micromanagement level to a hands-off level of mission specification. This calls for a more immersive interaction with the environment with tools for designating waypoints, samples to be collected, regions of hazard and interest, and other types of features. This type of environment is applicable to both rover navigation and operations with robotic arms and sensors. In addition, Web-based tools allow for collaboration by remote scientists in designating features of interest in a similarly immersive environment, and the exploration of the terrain by the public.

Three-dimensional visualization also has applications in telemetry monitoring and review. Tools for interpreting telemetry and visualizing sensor data through articulation of 3D CAD models of spacecraft are under development. Additional feedback includes color changes to warn of temperature over and under limits and opacity changes to indicate firing of thrusters.

These tools comprise a system for immersing the operator in the environment of another planet, body, or space to make the mission planning function more intuitive and effective.